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INFLUENCE OF CHEMICAL TREATMENTS AND POLYETHYLENE BAGS ON KEEPING QUALITY OF FLORIDA GRAPEFRUIT1/

by

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In the past the Florida citrus industry has had difficulty in marketing all its grapefruit. Consequently, certain sizes and crops of fruit have gone unpicked. The industry would benefit by an extension of the harvesting season provided decay was controlled and quality in fruit maintained. The consumer would also benefit by being assured a supply of good quality grapefruit during the summer.

Herein are reported the effects of prestorage chemical treatment of Marsh grapefruit from different groves and the use of various liner combinations on keeping quality. The studies were conducted at Orlando, Fla., and New York City, N. Y., in 1953, and were a part of the investigation on the storage of citrus fruit conducted by the Biological Sciences Branch, Agricultural Marketing Service, U. S. Department of Agriculture, and the Refrigeration Research Foundation, Colorado Springs, Colo.

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SUMMARY AND DISCUSSION

The tests reported on here showed that grapefruit can be held successfully at 32°F. for about 4 weeks. Some control of decay resulted from prestorage chemical treatments with (a) Dowicide A (sodium orthophenylphenate)-hexamine (hexamethylene-tetramine) and (b) 2-aminopyridine--pyrrolidine, but control was not sufficient to increase storage life. The borax treatment weakened the fruit and made it susceptible to storage pitting and decay. Spoilage was caused mostly by penicillium rots, although some stem-end rot and watery breakdown occurred, especially in lots held 8 weeks at 32° plus 7 days at 70°.

The keeping quality of Florida grapefruit stored at 32°F. in polyethylene bags and lined boxes was determined. The carbon dioxide and oxygen atmospheres within the bags were partly controlled by breaking the seals on the bags at definite times. Some treatments showed promise for short storage periods, but 9 weeks at 32° proved too long, because high percentages of decay developed after removal from cold storage. Fruit stored in polyethylene bags was usually soft. If the seals were not broken on the polyethylene bags off-flavors developed in the fruit.

MATERIAL AND METHODS

In 1953, storage studies with Florida grapefruit were conducted at Orlando, Fla., and New York, N. Y. The tests at Orlando were with Marsh fruit grown on rough lemon rootstock in groves in central Florida. Those at New York were with Marsh fruit grown on sour orange rootstock in a grove near Fort Pierce, Fla.

The commercial packinghouse treatments consisted of washing, waxing, polishing, grading, sizing, and packaging the fruit. For the storage tests at Orlando the fruit was packed in standard wire-bound Bruce boxes, whereas for those in the New York tests it was packed in standard partitioned nailed boxes. These commercially treated lots of fruit without further treatments represented the "controls".

At Orlando, three chemical treatments were tested for control of decay in stored grapefruit, namely, Dowicide A-hexamine, 2-aminopyridine-pyrrolidine, and borax. Briefly, the Dowicide A-hexamine treatment consisted of immersing fruit for 2 minutes in a solution of 2 percent Dowicide A, 1 percent hexamine, and 0.05 percent Palmolive soap in the dip tank. The commercial handling and packaging of fruit occurred about 4 hours after the chemical treatment. The 2-aminopyridine-pyrrolidine treatment consisted of immersing fruit for 2 minutes in a solution of 2.5 percent 2-aminopyridine and 2.5 percent pyrrolidine in the dip tank. The fruit was packaged about 4 hours after treatment. The borax treatment consisted of immersing the fruit for 10 seconds in a 5-percent solution of borax in the dip tank. Commercial handling and packaging of fruit followed about 24 hours after the dip treatment.

The Marsh grapefruit used in the New York tests was picked April 28, 1953, packed and shipped April 29, and unloaded in New York City on May 4. Some boxes were packed with polyethylene bags (.002 inch thick) with paper liners (outside the polyethylene) to protect the polyethylene. Although plain paper liners would have been used, if available, to protect the polyethylene bags, the liners were biphenyl-treated as they were the only ones available. Some lots were packed in boxes with biphenyl-treated liners only, as indicated in tables 5 to 7. The fruit, which graded U.S. No. 1 Bronze, was packed in standard nailed 1 3/5-bushel crates and shipped in a fan car containing 512 boxes. The car was initially iced and reiced once in transit. Initial fruit temperatures averaged 75° F. and arrival temperature 44°. Average transit temperature was 60°.

Storage temperature at Orlando was 32° F. and relative humidity 80 percent. At New York the storage temperature was 32° and relative humidity 90 percent, except for those boxes "purged" or stored at alternating temperatures. Purging consisted of transferring the fruit to 70°, relative humidity 75 percent, for a 2-day period at the intervals indicated in tables 5 to 7. Average pulp temperatures reached 59° after this period. The fruit stored at alternating temperatures was alternated at weekly intervals between 50°, relative humidity 85 percent, and 32° with the first week's storage at 50°.

The tests were designed to determine the effects of the following on quality of stored Marsh grapefruit:

1. Treatment with Dowicide A-hexamine and storage for 4 and 8 weeks at 32° F.

2. Treatment with 2-aminopyridine-pyrrolidine and storage for 4 and 8 weeks at 32° F.

3. Treatment with borax and storage for 4 and 8 weeks at 32° F.

4. Storage of fruit from different crops for 4 and 8 weeks at 32° F.

5. Exposing the fruit to higher temperatures (50° and 70° F.) at intervals during the storage period to determine whether this practice would reduce the amount of pitting that occurs with continuous storage at 32°.

6. Build-up of carbon dioxide and reduction of oxygen by storing in polyethylene bags inside lined boxes. Three methods of using polyethylene bags were tried as follows:

    a. Sealing by tying the twisted film and breaking the seal when the fruit was removed from cold storage.

    b. Sealing as in (a) but keeping the package sealed during the 7-day holding period at 70° F. when the fruit was removed from cold storage.

    c. No sealing.

Each of the subsamples, including the "controls", consisted of 5-box lots. At the end of the storage periods indicated in tables 1 to 7, the fruit was removed from storage and inspected. It was then placed in a 70° F. room, relative humidity 84 percent, to determine market life, and reinspected after 3 days and again after 7 days.

To indicate the condition of the New York-stored fruit prior to storage, 5-box samples that had been given 3 of the treatments were inspected on arrival in New York and again after 3 days' and 7 days' holding at 70°. The treatments were (1) no liner, (2) biphenyl liner and (3) sealed polyethylene bags (inspected after 7 days only).

The method of inspection of fruit was similar to that used in the earlier test.2/ Fruit showing both aging and pitting was scored under the defect considered the more serious. Decay was always considered more serious than any type of skin breakdown. Decayed fruits were scored under stem-end rot when the symptoms were characteristic of diplodia rot or phomopsis rot, regardless of where the decay occurred. Three inspections were made, at the time the boxes of fruit were removed from storage and after 3 and 7 days at 70° F.

At the first and second inspections decayed grapefruit was discarded before the sound fruit was repacked in the test boxes. The amounts of decay for the second and third inspections are cumulative; that is, they include decay counts for all previous inspections. Pitting and aging records at the second and third inspections are not cumulative, but are based on actual counts made at the particular inspection.

RESULTS

Effect of Prestorage Chemical Treatment on Marsh Grapefruit Stored April 21 and May 6 at Orlando, Fla.

In general, keeping quality of grapefruit was good and percentages of decay small at the end of 4 and 8 weeks' storage at 32° (table 1). Decay did develop during the 7-day holding period at 70° and the development was particularly rapid between the third and the seventh day. Total decay was associated with length of storage, and smaller amounts occurred in the lots stored 4 weeks than in those stored 8 weeks.

The prestorage chemical treatments with Dowicide A-hexamine or 2-amino-pyridine-pyrrolidine had slight effect on decay during either storage or the holding period at 70° F. Borax treatment was ineffective in the control of decay. Borax-treated lots generally had more decay than the "control" lots at the end of the 7-day holding period. Very little rind pitting developed during storage at 32° (table 2). Moderate and severe pitting was related to the length

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2/ Harding, Paul L., Friedman, B. A., Sunday, M. Bryan, Kaufman, J., and Hruschka, H. W. The Effect of Prestorage Treatments and Storage Temperatures on the Keeping Quality of Florida Grapefruit at Orlando, Fla., and New York City, N. Y. H.T.&S. Office Report No. 285, pp. 28, 1952.

of the storage and was more serious in fruit stored 8 weeks than in that stored 4 weeks. Pitting was somewhat related to prestorage chemical treatments, and more pitting was generally found on the grapefruit treated with Dowicide A-hexamine and borax than on that treated with 2-aminopyridine-pyrrolidine.

Variation in Keeping Quality of Fruit from Different Groves

Fruit from different groves varied considerably in storage quality (table 3 and 4). There appears to be no accurate fast test for determining which fruit are strong or weak for storage. An attempt was made to study the effects of chemical treatments on fruit of good and poor keeping quality, but the results were inconsistent and showed that complete reliance could not be placed on memory of the grower as to past performance. Another point of interest brought out by these studies was that certain lots of fruit with low records of decay after 4 weeks' storage were not the low lots after 8 weeks' storage.

Moderate and severe pitting appeared to be associated with specific crops.

Effect of Polyethylene Bags on Marsh Grapefruit Stored May 4 at New York, N. Y.

Decay, pitting, and aging before storage.- Decay was relatively low prior to storage, averaging 1, 3 and 6 percent, respectively, after 0, 3 and 7 days' holding at 70° F. Moderate and severe pitting at prestorage inspections was slight, averaging less than 1 percent after 7 days. Aging was negligible. All the fruit was in good condition; that stored in polyethylene bags was a little firmer than the rest. No off-flavor was noted.

Decay after storage - About 2/3 of the decay in the New York tests was penicillium rot and most of the rest was stem-end rot. Decay (table 5) after 4 weeks' storage was very low when the fruit was removed from storage and even after 3 days at 70° F. none of the lots had over 8 percent. After 7 days at 70°, decay ranged from 14 to 40 percent in all lots except in the lot stored in polyethylene bags in paper-lined boxes in which the seal was not broken when the crates were removed from storage. Here 3 percent of the fruit was decayed. However, the fruit given this treatment was soft and decidedly off-flavor.

After 9 weeks' storage, all lots at temperatures above 32° F. for all or a part of the time had 13 percent or more decay. Those stored at 32° continuously had 8 percent or less decay when removed from storage. However, decay in this fruit increased rapidly after removal from storage. The non-sealed polyethylene lot was the only lot containing less than 12 percent decay after 3 days at 70°. This fruit was somewhat soft and decayed very fast upon further holding. Approximately 5 percent of the fruit in sealed polyethylene bags in paper-lined boxes had watery breakdown when it was removed from storage after a 9-week holding period. This increased to 15 percent in 3 days. Only an occasional fruit with watery breakdown was found in the lots stored without polyethylene bags.

Pitting and aging after storage - Pitting (table 6) was not important either upon removal after 4 weeks' storage or after a holding period at 70° F., except in the lot stored with biphenyl liners only. Here 11 percent of the fruit had moderate and severe pitting after 3 days. The results obtained in 1952 also showed slightly increased pitting when biphenyl liners were used.

After 9 weeks' storage, pitting was generally higher in all lots and an appreciable amount was found on removal and after a holding period in the fruit stored at 32° F. without liners or with biphenyl liners only. Pitting was fairly well controlled by polyethylene bags and alternating temperatures or purging. The apparent decrease in pitting after longer holding, particularly after 7 days at 70° following 9 weeks' storage, is due to decay entering pits so that the individual fruits were scored as decayed at this final inspection.

Aging (table 7) was not serious in any of the lots except those stored at 50° F. continuously or at the alternating temperatures of 50° to 32°.

Flavor and gas analyses - Serious off-flavor was observed in the fruit stored in sealed polyethylene bags in paper-lined boxes when the seals were not broken until 7 days after removal from either 4 or 9 weeks' storage. It can be noted in table 8 that carbon dioxide built up in those lots to a maximum of 31.8 percent and oxygen was down to less than 2 percent. None of the other polyethylene lots held for 4 weeks had off-flavor after a 7-day holding period, but all polyethylene lots had off-flavors after 9 weeks. The off-flavor in the non-sealed polyethylene was a little surprising, but folding over the top of the bags as was done in these tests did allow carbon dioxide to build up to 8.4 percent.

Table 1.--Decay of Marsh grapefruit chemically treated before storage at 32° F. and subsequent holding for 0 to 7 days at 70°, Orlando, Fla.

[Each value is an average from 5-box lots]

Date of storage and fruit treatment	Fruit decayed after 4 weeks' storage + indicated period at 70°			Fruit decayed after 8 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
	Percent	Percent	Percent	Percent	Percent	Percent
April 21, 1953:						
None (Control)	0	0	25	1	4	32
Dowicide A-hexamine	0	0	20	0	1	30
2-aminopyridine-pyrrolidine	0	2	23	0	2	39
Borax	0	1	45	0	6	61
May 6, 1953:						
None (Control)	1	2	40	0	11	76
Dowicide A-hexamine	0	1	40	1	8	62
2-aminopyridine-pyrrolidine	0	1	36	1	16	73
Borax	1	1	68	1	13	82

Table 2. Moderate and severe pitting of Marsh grapefruit chemically treated before storage at 32°F. and subsequent holding for 0 to 7 days at 70°, Orlando, Fla.

[Each value is an average from 5-box lots]

Date of storage and fruit treatment	Fruit pitted after 4 weeks' storage + indicated period at 70°			Fruit pitted after 8 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
	Percent	Percent	Percent	Percent	Percent	Percent
April 21, 1953:						
None (Control)	0	2	1	4	17	15
Dowicide A-hexamine	1	1	2	4	8	9
2-aminopyridine-pyrrolidine	0	1	1	2	7	4
Borax	0	5	7	0	9	14
May 6, 1953:						
None (Control)	0	0	0	0	6	2
Dowicide A-hexamine	0	0	0	0	6	6
2-aminopyridine-pyrrolidine	0	1	1	0	2	0
Borax	0	0	1	0	3	1

Table 3. Decay in Marsh grapefruit of various crops stored at 32°F. and subsequent holding for 0 to 7 days at 70°, Orlando, Fla., May 7-18, 1953.

[Each value is an average from 5-box lots]

Crop	Fruit decayed after 4 weeks' storage + indicated period at 70°			Fruit decayed after 8 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
	Percent	Percent	Percent	Percent	Percent	Percent
A	0	1	35	1	16	82
B	0	1	15	1	10	77
C	0	0	12	1	9	89
D	1	2	15	1	21	68
E	0	0	13	2	12	68

Table 4. Moderate and severe pitting of Marsh grapefruit of various crops stored at 32°F. and subsequent holding for 0 to 7 days at 70°, Orlando, Fla., May 7-18, 1953.

[Each value is an average from 5-box lots]

Crop	Fruit pitted after 4 weeks' storage + indicated period at 70°			Fruit pitted after 8 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
	Percent	Percent	Percent	Percent	Percent	Percent
A	0	0	0	0	1	1
B	1	1	1	0	4	1
C	0	1	0	0	5	0
D	1	4	1	2	11	4
E	0	0	1	1	7	1

Table 5. Decay in Marsh grapefruit stored at various temperatures and in boxes with different types of liners, New York, N. Y., May 4, 1953

/Each value is an average from 5-box lots/

Temperature of storage and other treatments	Fruit decayed after 4 weeks' storage + indicated period at 70°			Fruit decayed after 9 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
32°F. without purging:	Percent	Percent	Percent	Percent	Percent	Percent
Without liner	1	3	18	3	13	73
With biphenyl liner only	2	2	14	1	12	63
With biphenyl liner + sealed polyethylene bag with seal broken at removal from 32°	(1/)	2	40	8	14	94
With biphenyl liner + sealed polyethylene bag with seal not broken at removal from 32°	-	-	3	-	-	68
With biphenyl liner + non-sealed polyethylene bag	1	2	19	2	8	96
32°F., purged weekly at 70°, without liner	4	6	18	16	28	50
32°F., purged biweekly at 70°, without liner	2	3	21	13	26	53
50°F. - 32°, alternating, without liner	2	3	20	18	31	50
50°F., without liner	5	8	28	43	53	67

1/ Less than 0.5 percent

Table 6. Moderate and severe pitting in Marsh grapefruit stored at various temperatures and in boxes with different types of liners, New York, N. Y., May 4, 1953

[Each value is an average from 5-box lots]

Temperature of storage and other treatments	Fruit pitted after 4 weeks' storage + indicated period at 70°			Fruit pitted after 9 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
32°F. without purging:	Percent	Percent	Percent	Percent	Percent	Percent
Without liner	1	2	1	6	11	4
With biphenyl liner only	2	11	9	10	16	9
With biphenyl liner+ sealed polyethylene bag with seal broken at removal from 32°	(1/)	1	5	1	1	0
With biphenyl liner + sealed polyethylene bag with seal not broken at removal from 32°	-	-	(1/)	-	-	0
With biphenyl liner + non-sealed polyethylene bag	1	3	3	2	4	1
32°F., purged weekly at 70°, without liner	1	3	2	1	1	0
32°F., purged biweekly at 70°, without liner	(1/)	1	(1/)	4	4	1
50°F. - 32°, alternating, without liner	3	3	3	2	2	0
50°F., without liner	2	2	0	2	2	0

1/ Less than 0.5 percent.

Table 7. Severe aging in Marsh grapefruit stored at various temperatures and in boxes with different types of liners, New York, N. Y., May 4, 1953

/Each value is an average from 5-box lots/

Temperature of storage and other treatments	Fruit aging after 4 weeks' storage + indicated period at 70°			Fruit aging after 9 weeks' storage + indicated period at 70°		
	0 day	3 days	7 days	0 day	3 days	7 days
32°F. without purging:	Percent	Percent	Percent	Percent	Percent	Percent
Without liner	1	2	1	2	2	2
With biphenyl liner only	1	2	1	2	3	1
With biphenyl liner + sealed polyethylene bag with seal broken at removal from 32°	0	0	0	0	0	0
With biphenyl liner + sealed polyethylene bag with seal not broken at removal from 32°	-	-	0	-	-	0
With biphenyl liner + non-sealed polyethylene bag	0	(1/)	1	(1/)	(1/)	(1/)
32°F., purged weekly at 70°, without liner	2	1	1	1	1	(1/)
32°F., purged biweekly at 70°, without liner	1	2	2	2	2	2
50°F. - 32°, alternating, without liner	3	5	4	8	4	2
50°F., without liner	6	8	6	4	4	1

1/ Less than 0.5 percent.

Table 8. Atmosphere in polyethylene bags packed with Marsh grapefruit and stored at New York, N. Y., May 4, 1953

/Each value is an average from 5-box lots/

Storage period and sealing	Carbon dioxide				Oxygen			
	When removed from 32°F.		After 7 days at 70°F. 1/		When removed from 32°F.		After 7 days at 70°F. 1/	
	Average Percent	Maximum Percent	Average Percent	Maximum Percent	Average Percent	Maximum Percent	Average Percent	Maximum Percent
None (sealed liner) --------	--	--	10.2	12.0	--	--	6.9	3.7
4 weeks:								
Sealed bag ----------	12.8	15.4	21.2	26.0	2.9	0.5	0.8	0.1
Nonsealed bag ----------	4.1	5.0	--	--	15.1	14.0	--	--
9 weeks:								
Sealed bag ----------	12.1	15.4	29.4	31.8	2.8	1.0	2.0	0
Nonsealed bag ----------	3.9	8.4	--	--	16.0	12.0	--	--

1/ Seal not broken when removed from storage.